Validation of CERES ST Retrieved MODIS Cloud Properties Using DOE AMF-China and Cloudsat/CALIPSO Observations

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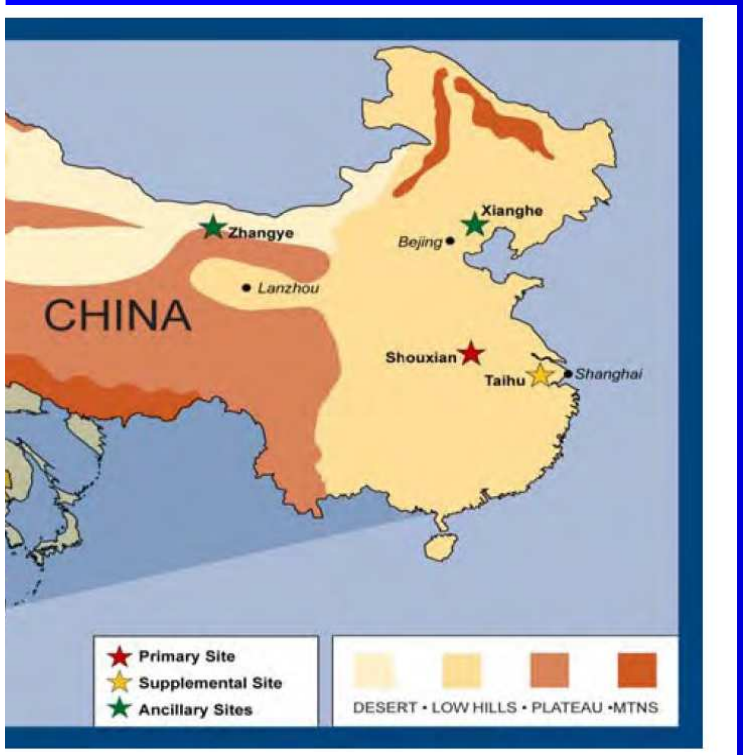
Objectives



1. Compare ARM radar-lidar derived cloud base and top heights with MODIS derived effective cloud height over Shouxian, China (ARM Mobile Facility, AMF, 32º33'N, 116º47'E).
2. Compare cloud microphysical properties derived from ARM radar-radiometer with CERES-MODIS retrievals.
3. Compare cloud profiles observed/ retrieved from CloudSat and ARM radar-radiometer with

DOE AMF-China Measurements and Retrievals

Hbase and Htop: Cloud-base and -top heights determined by ARM cloud radar-lidar measurements

Liquid water path (LWP): Microwave radiometer

Cloud droplet effective radius re: retrieved by radar reflectivity and LWP

Optical depth Tau: 1.5*LWP/re

All results are averaged over 1-hr period centered on TERRA overpass AMF-China site during Oct. 15 - Dec. 15, 2008.

CERES-MODIS cloud height and Microphysics (Ed_2G SSF products, TERRA only)

Effective cloud height H_{eff} : defined as the lowest altitude having T_{eff} in the GEOS vertical profile of atmospheric temperature.

Note that H_{eff} is the cloud radiative center from satellite point of view, not cloud physical center.

Daytime: the 4-channel VISST (Visible Infrared Solar-Infrared Split-window Technique).

Nighttime: the 3-channel Solar-infrared Infrared Split-window Technique [SIST].

Effective radius re: derived from 3.7-um radiance

Optical depth τ: visible (day) and solar-infrared (night)

LWP ~ re * τ

CloudSat/CALIPSO measurements/retrievals

- **CloudSat/Calipso (CC): (Results from CSU and CCCM)**

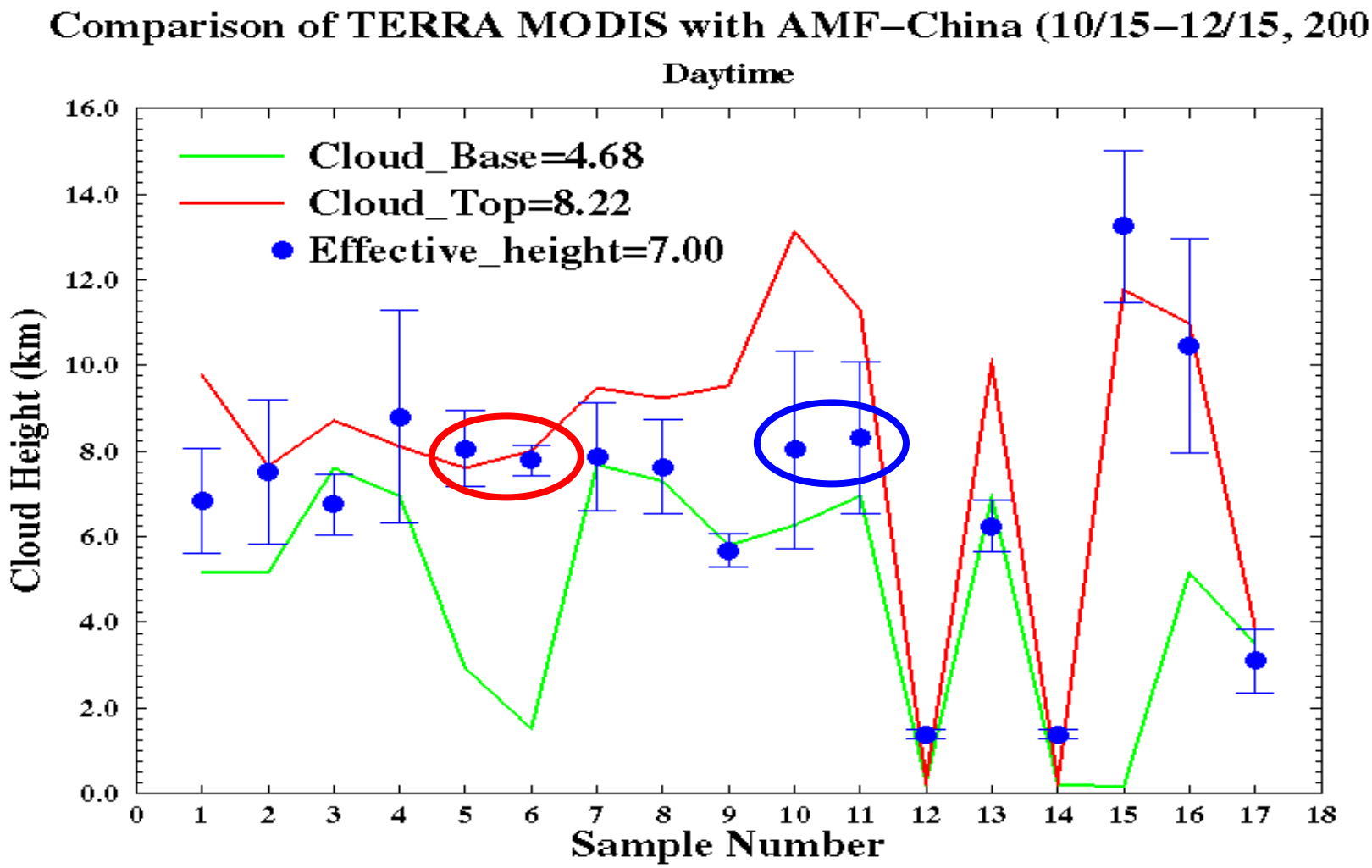
Level 2B data products, averages over a 1°x1° grid box

Hbase/Htop heights: determined by both 94 GHz radar and Lidar with a vertical resolution of 240 m.

Liquid/ice particle sizes and contents/paths: retrieved from 94 GHz radar (Radar only, works for both day and night time with higher uncertainty than radar+ visible optical depth)

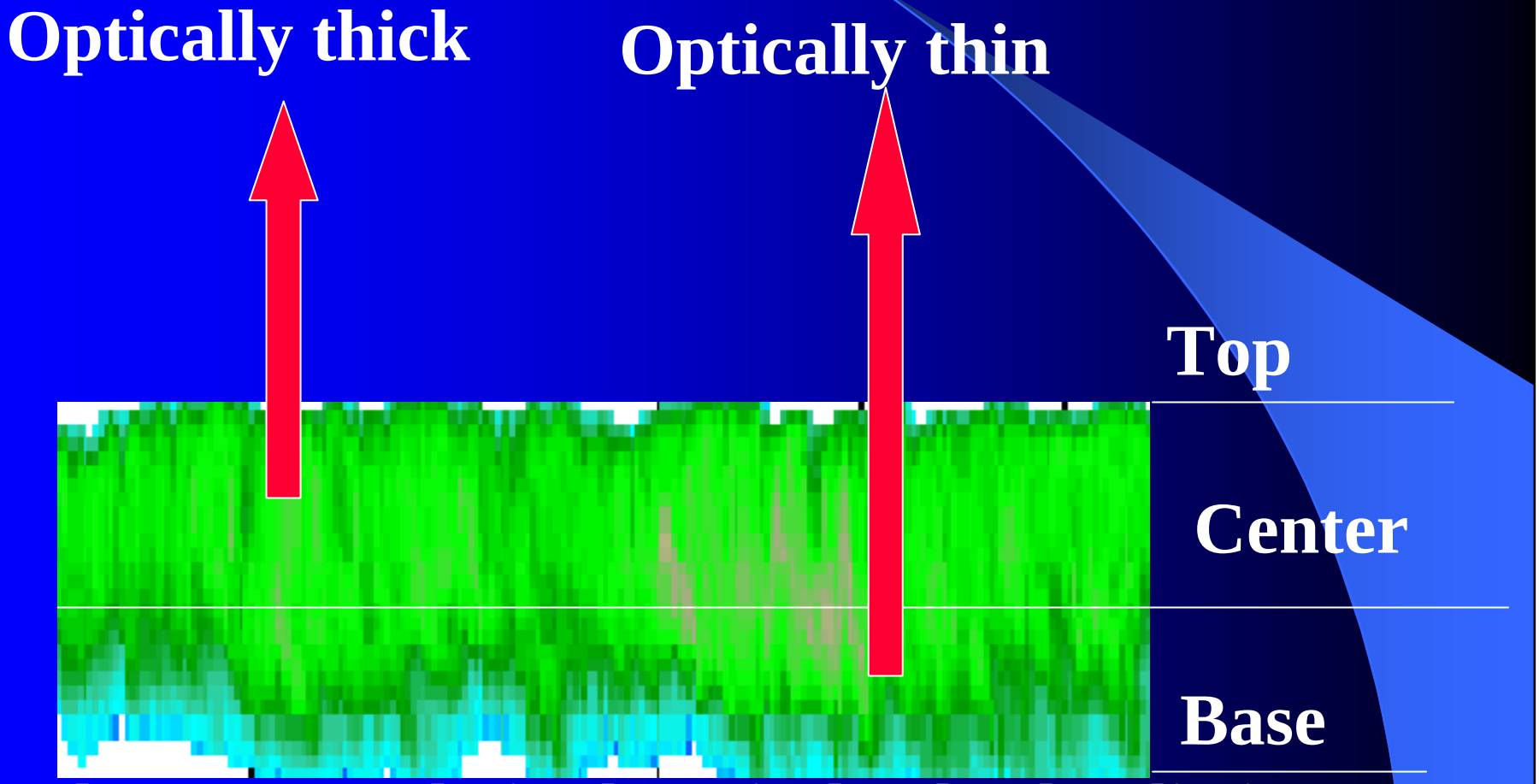
Objective 1:

Compare ARM radar-lidar derived cloud base and top heights with CERES-MODIS derived effective cloud height over Shouxian, China (ARM Mobile Facility, AMF, 32º33’N, 116º47’E).



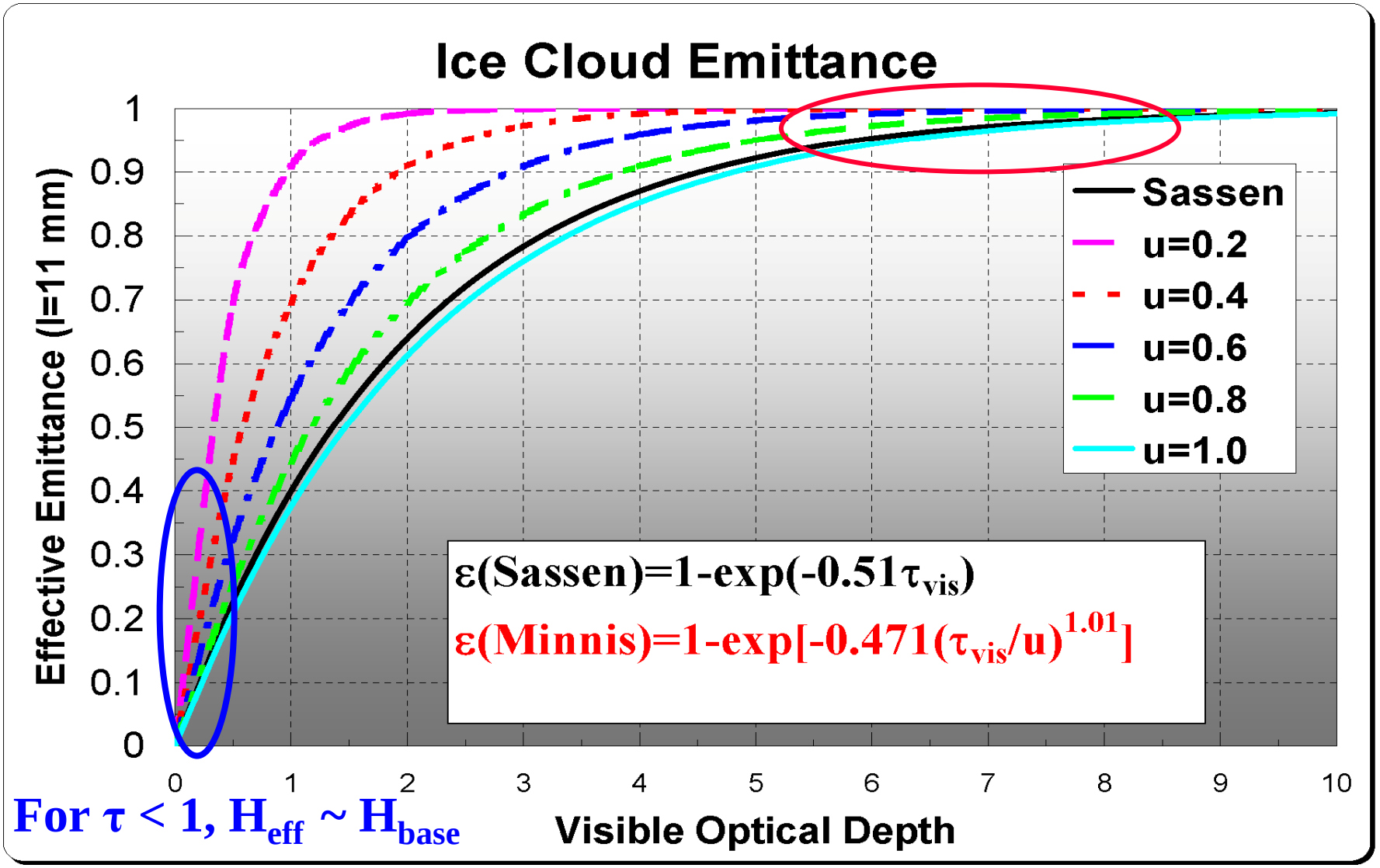
1. **Most of CERES-MODIS derived effective cloud heights H_{eff} are within ARM radar-lidar derived cloud bases and tops**
2. **But why some H_{eff} are close to cloud tops (Samples 5 and 6), while some (Samples 10 and 11) are near cloud centers or bases**

What results do we expect to get from the cloud height comparison ?

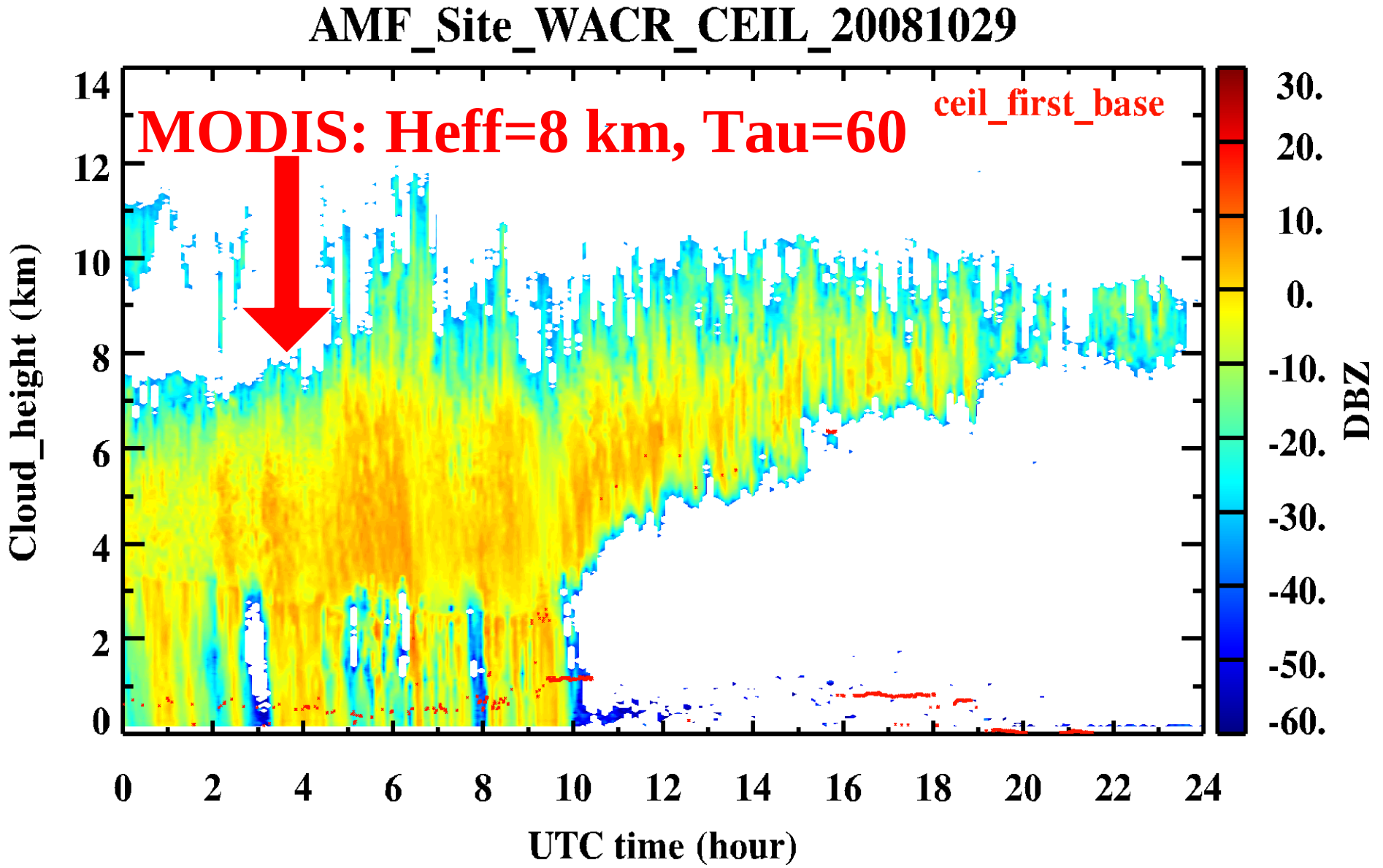


Note that MODIS derived H_{eff} is the cloud radiative center, not cloud physical center.

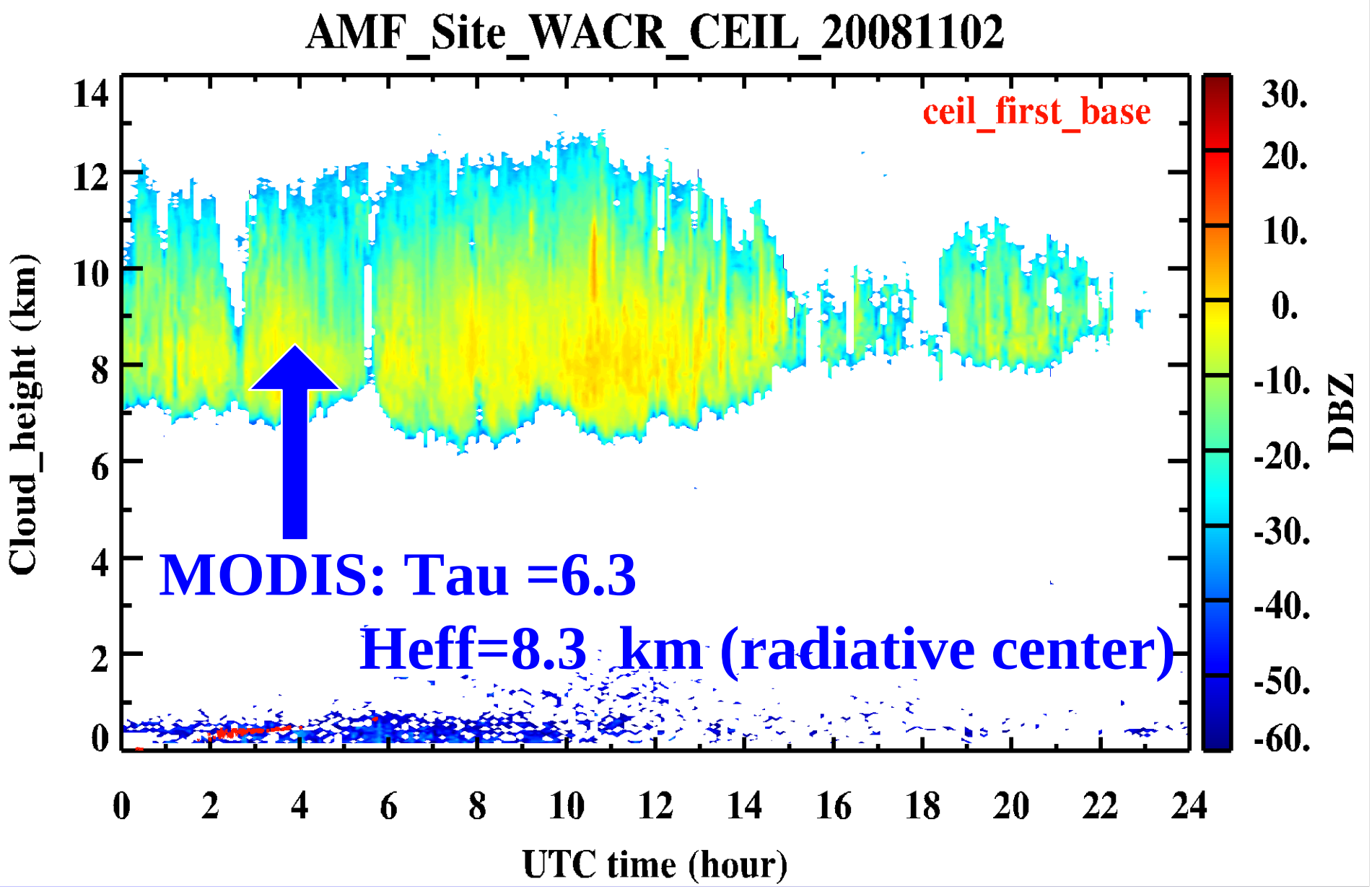
As $\tau \sim 5 \rightarrow \varepsilon \sim 1$, the radiance mostly from cloud top $\rightarrow H_{eff} \sim H_{top}$

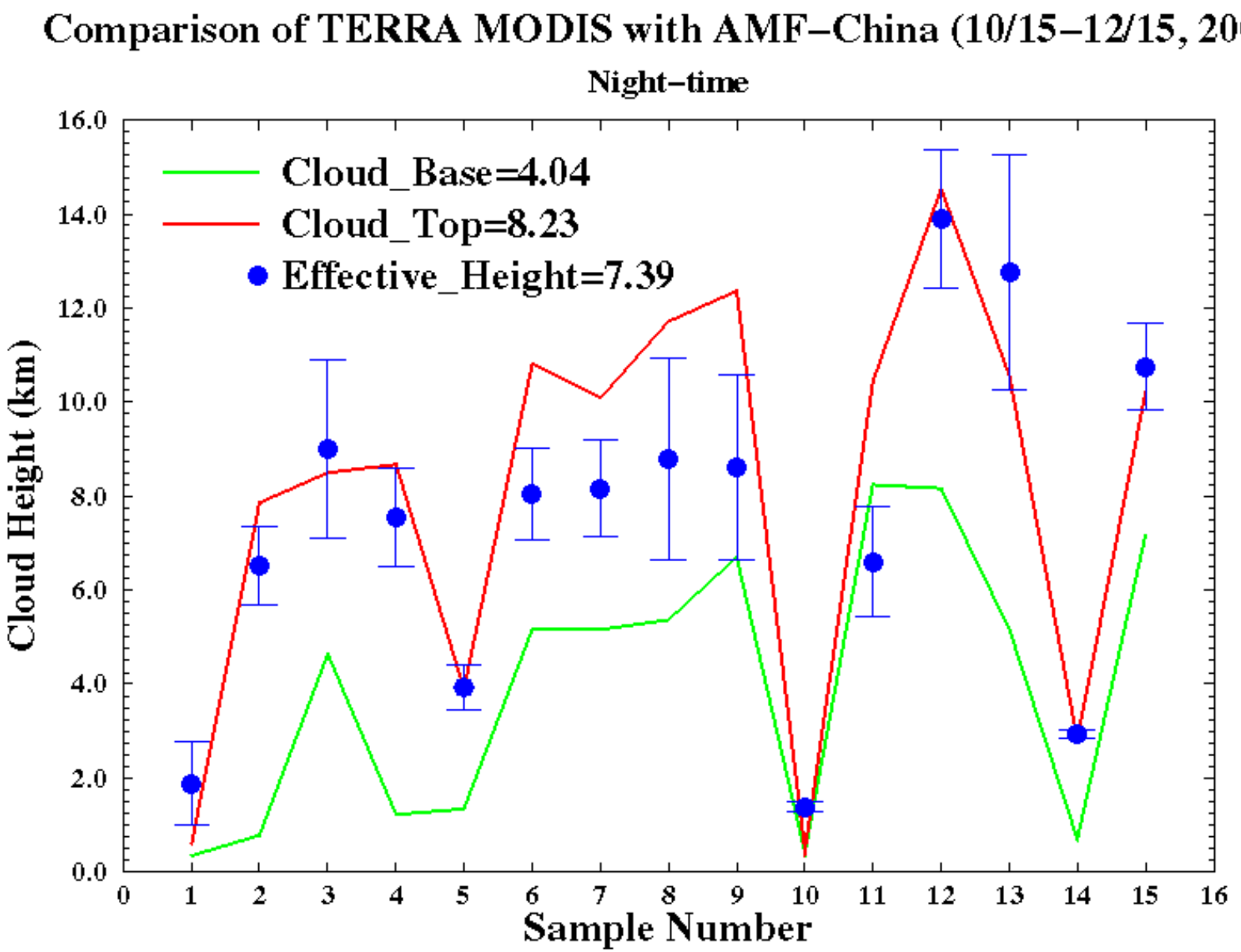


H_{eff} near cloud top (Sample 6)

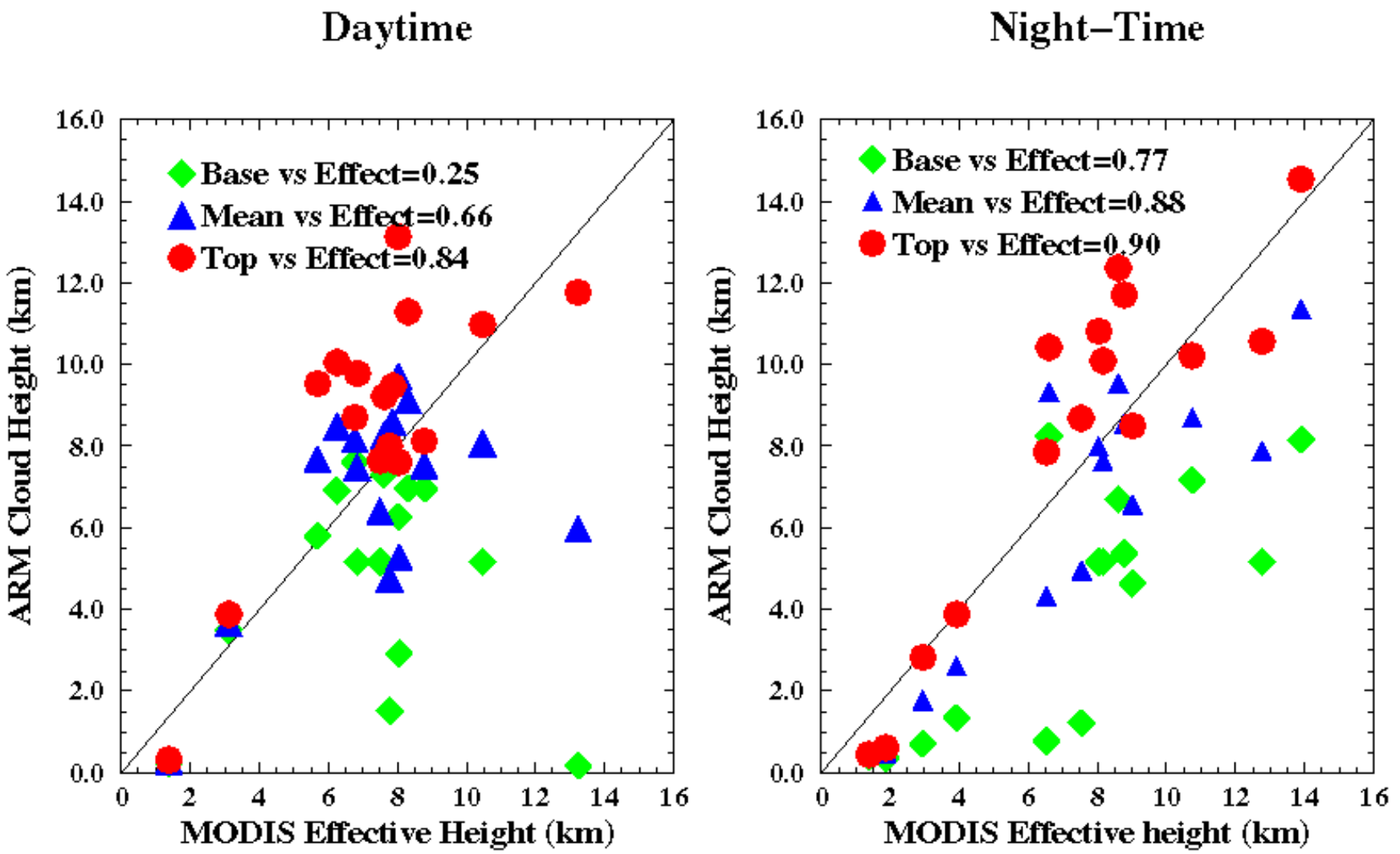


H_{eff} near cloud base (Sample 11)





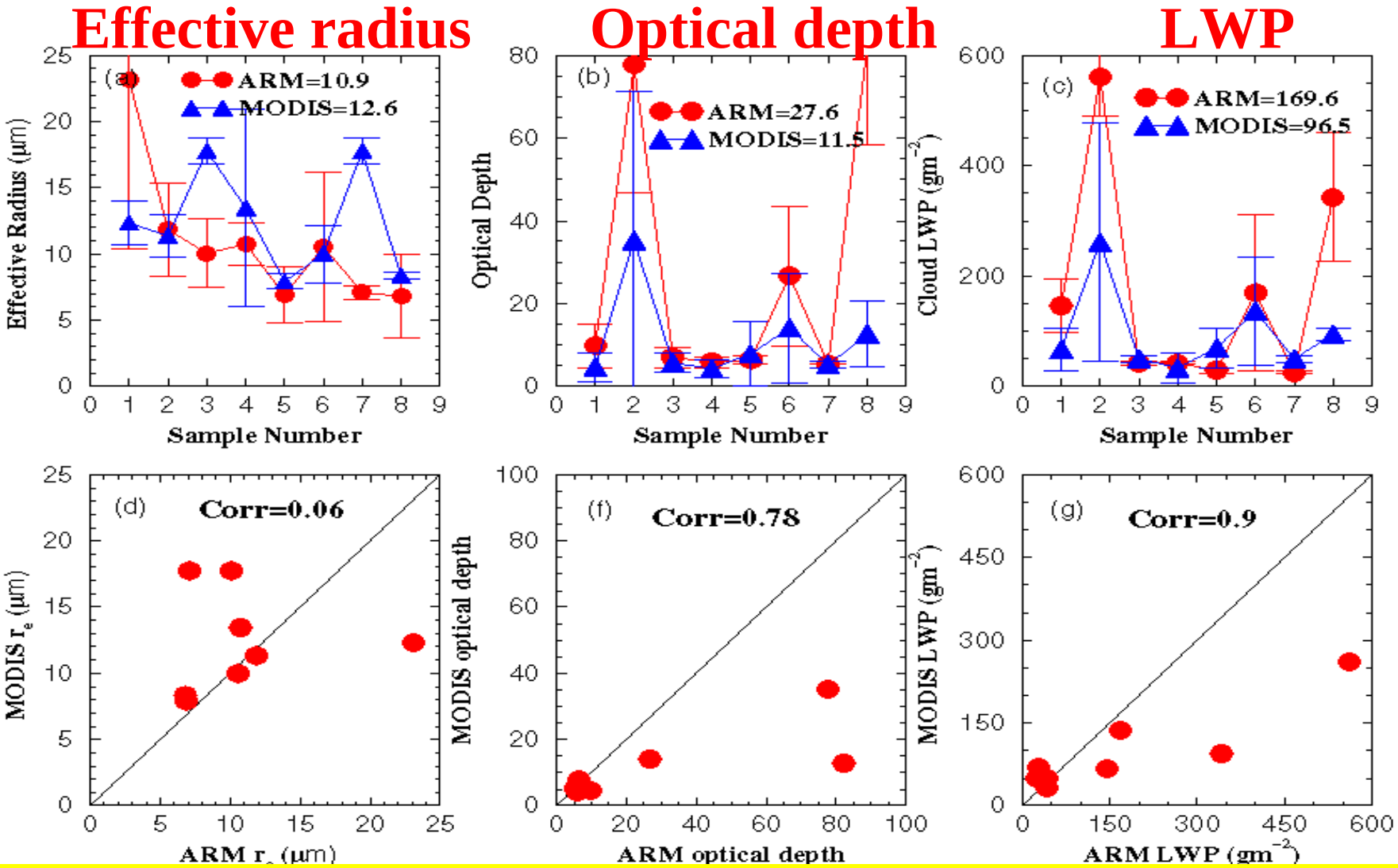
Nighttime comparison is similar to its daytime counterpart



1) Most of MODIS H_{eff} are around cloud centers (▲)
2) H_{eff} values have higher correlation with cloud tops

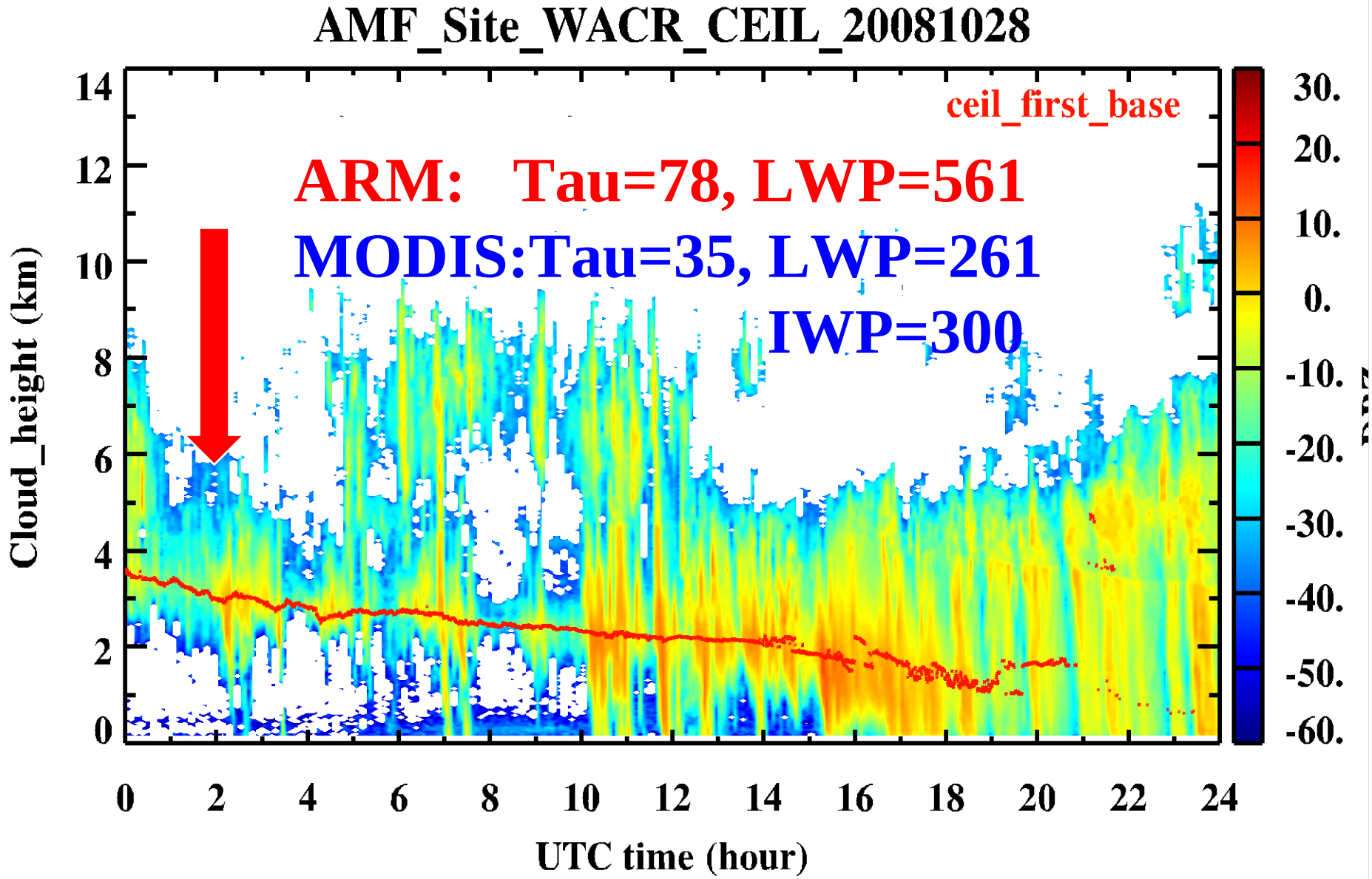
Objective 2

- **Compare cloud microphysical properties derived from ARM radar-radiometer with MODIS retrievals (liquid-phase only)**

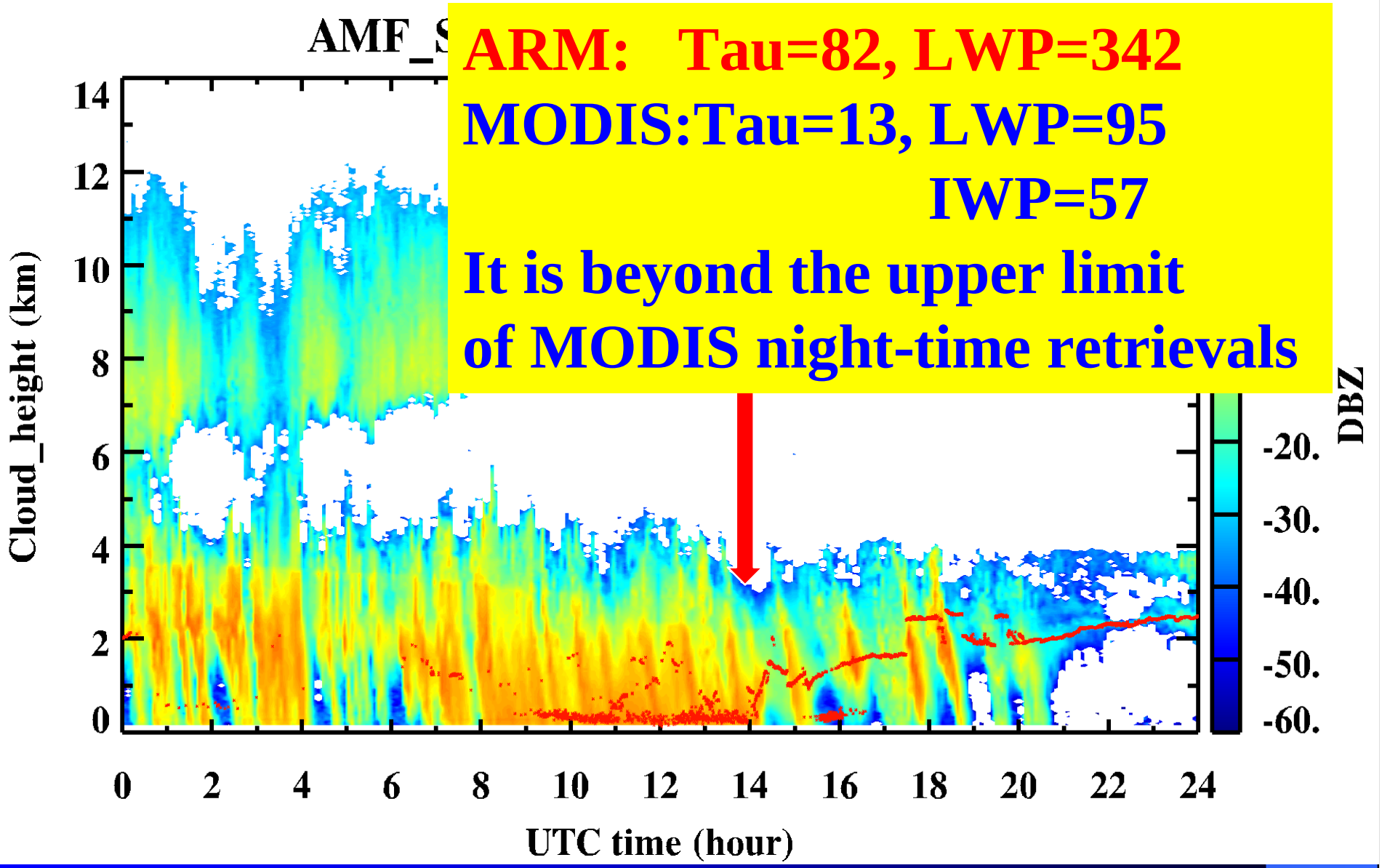


1) Re difference between ARM and MODIS is 1.7 μm with low correlation because MODIS re represents cloud top.
2) Correlations for optical depth and LWP are high, but MODIS values are smaller than ARM results, mainly from samples 2 and 8.

Sample 2: 20081028_02 UTC (daytime)



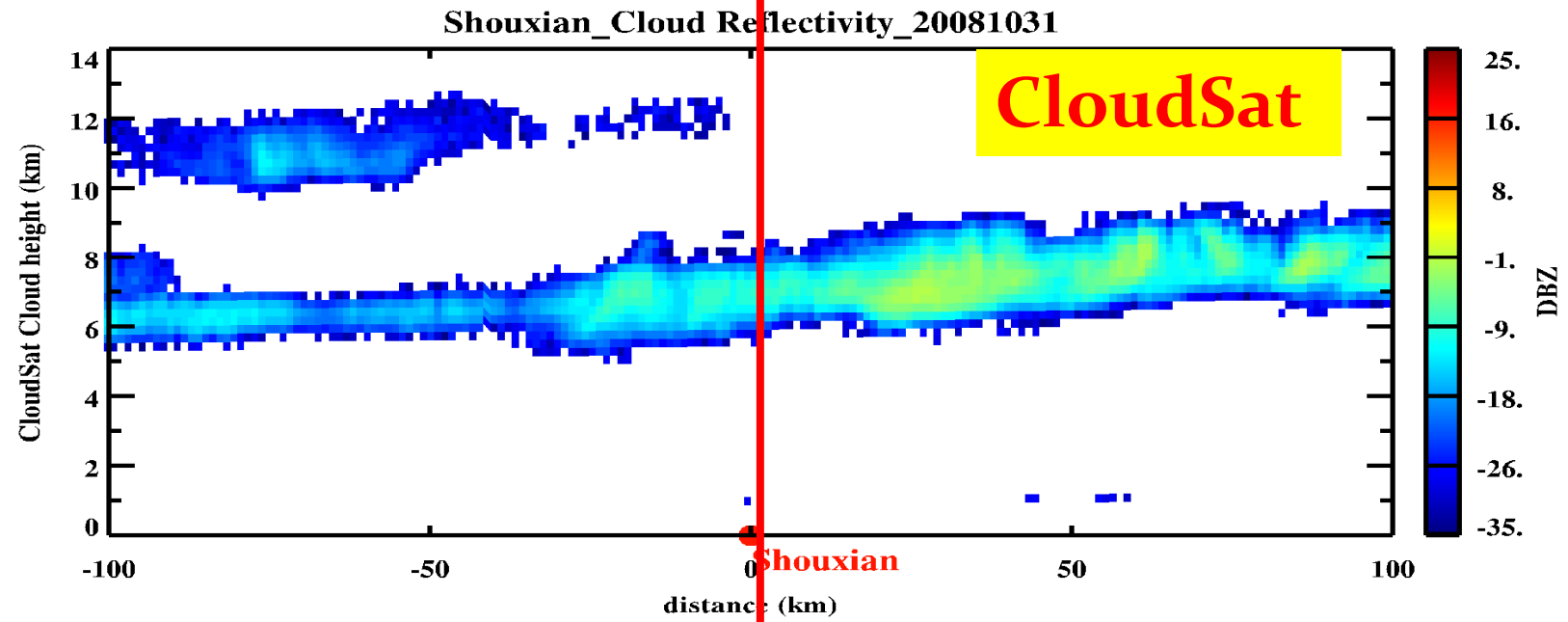
Sample 8: 20081107_14 UTC (Nighttime)

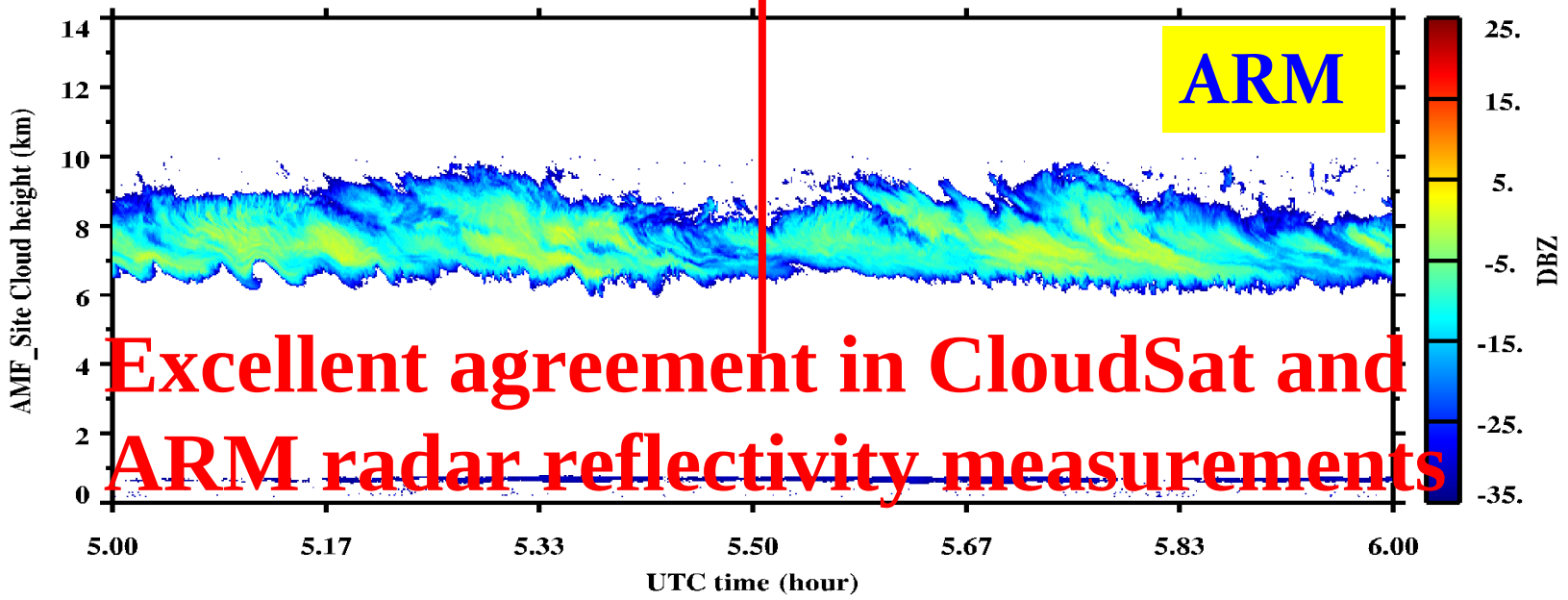


Objective 3

Compare cloud profiles observed/ retrieved from CloudSat and ARM radar-radiometer with MODIS retrievals

Case 1

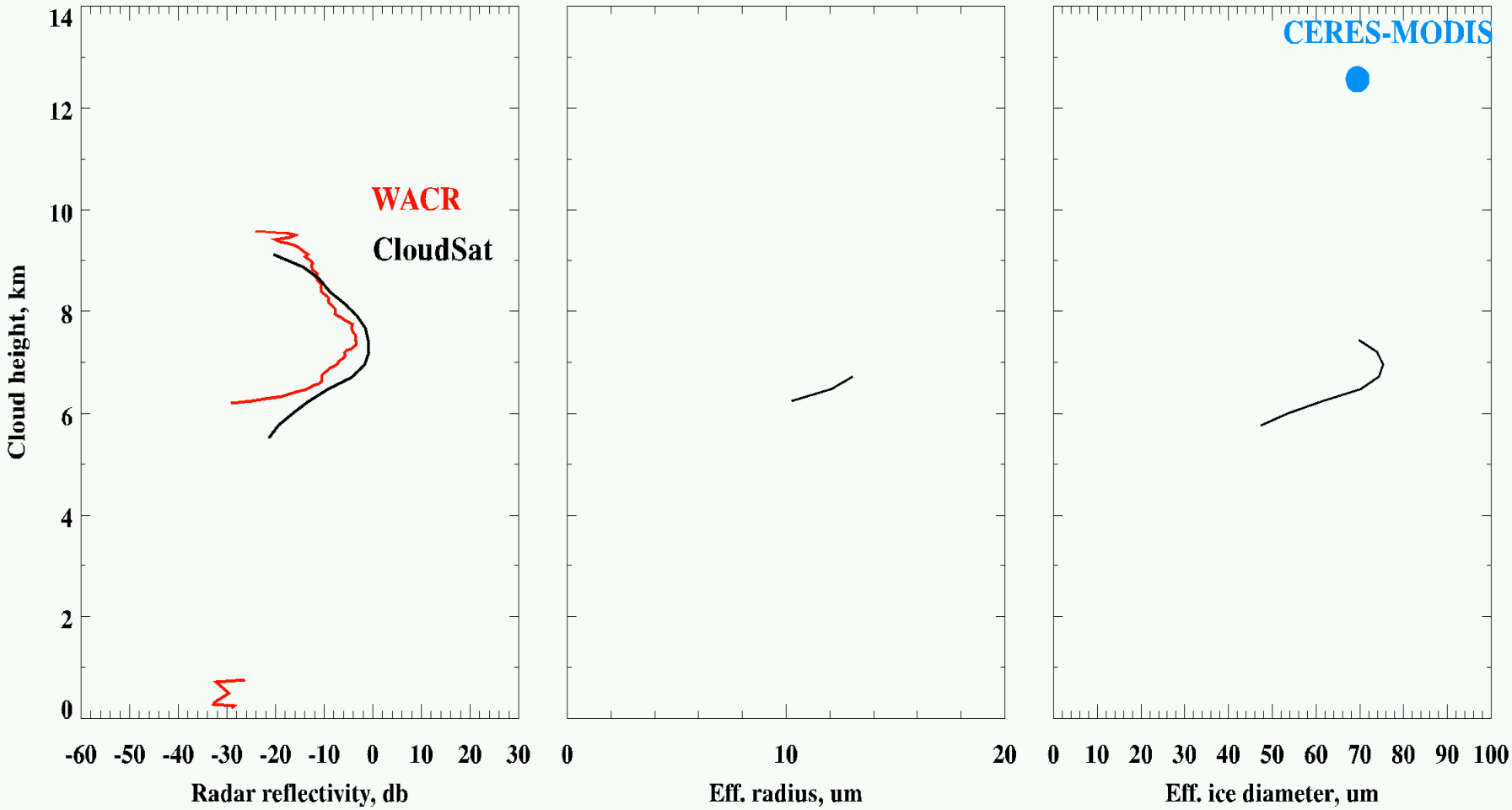




Excellent agreement in CloudSat and ARM radar reflectivity measurements

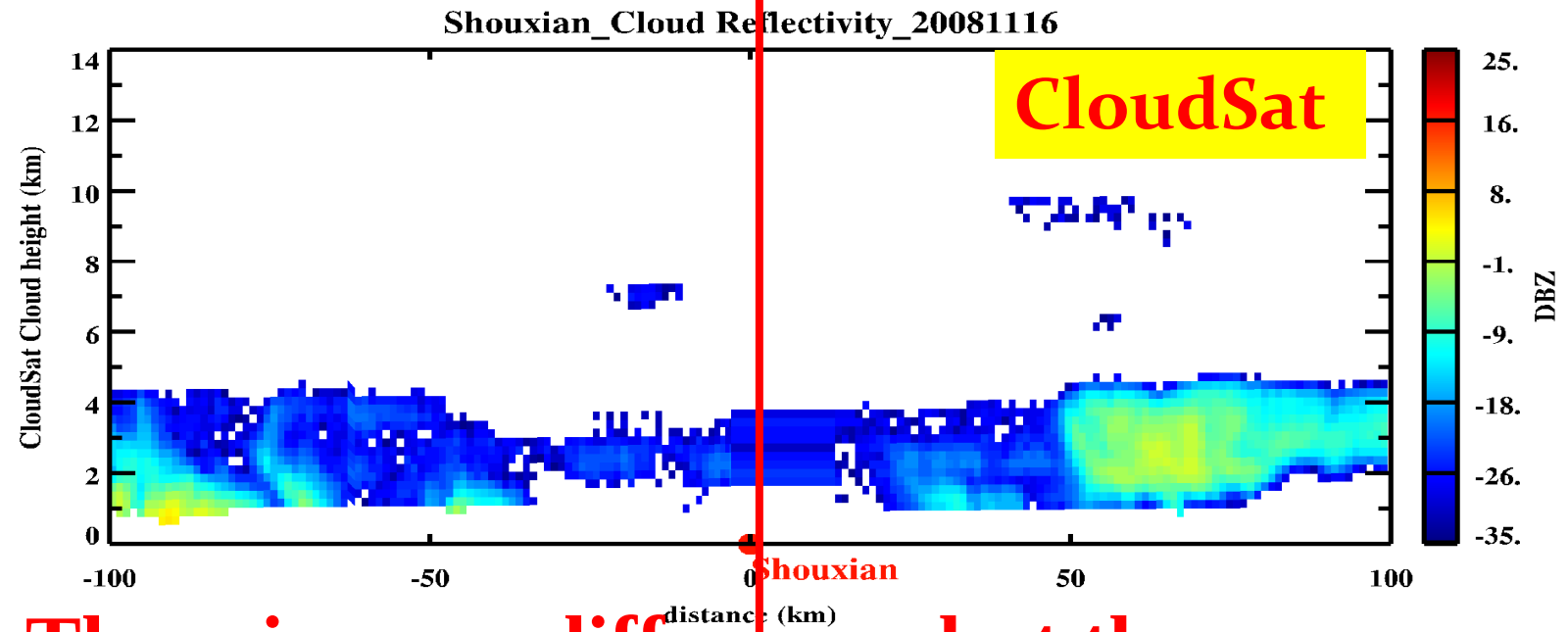
Case 1: 20081031

2) MODIS retrieved ice particle diameter is close to Cloudsat retrieval, but why its height is much higher than ARM and CloudSat/CALIPSO?

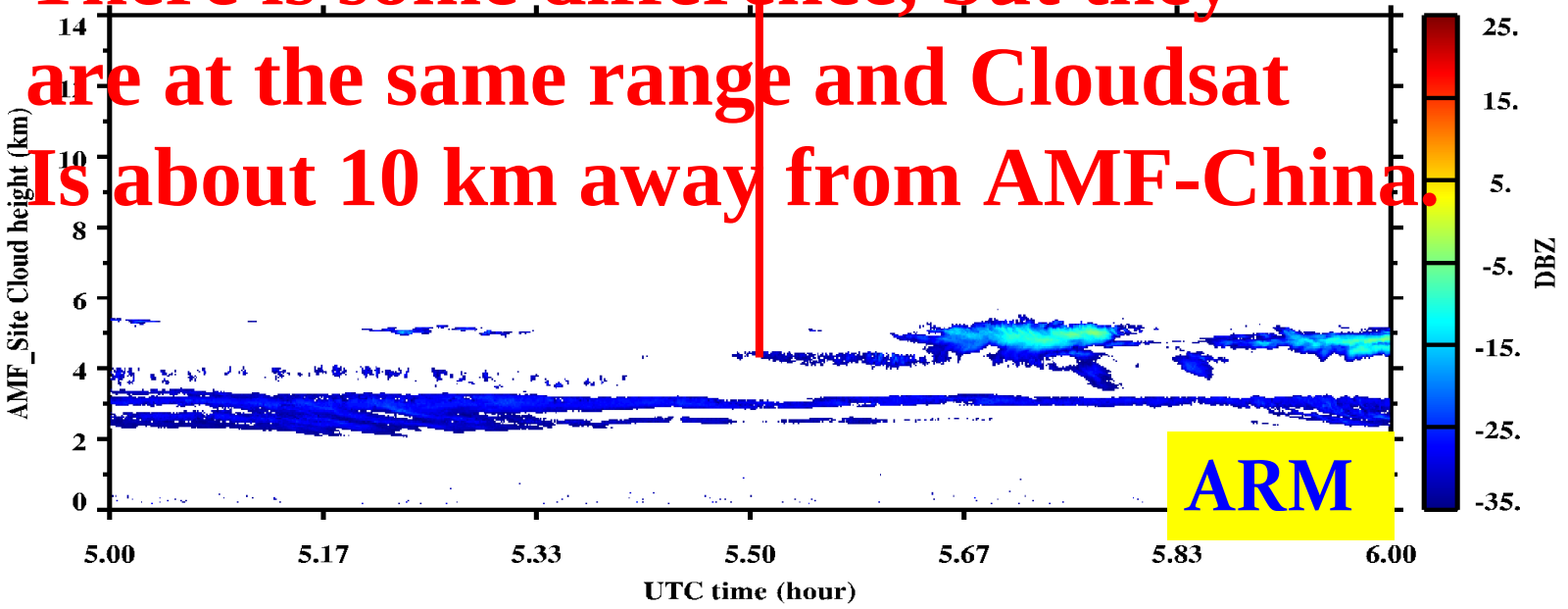


1) Excellent agreement in radar reflectivity between Cloudsat and ARM

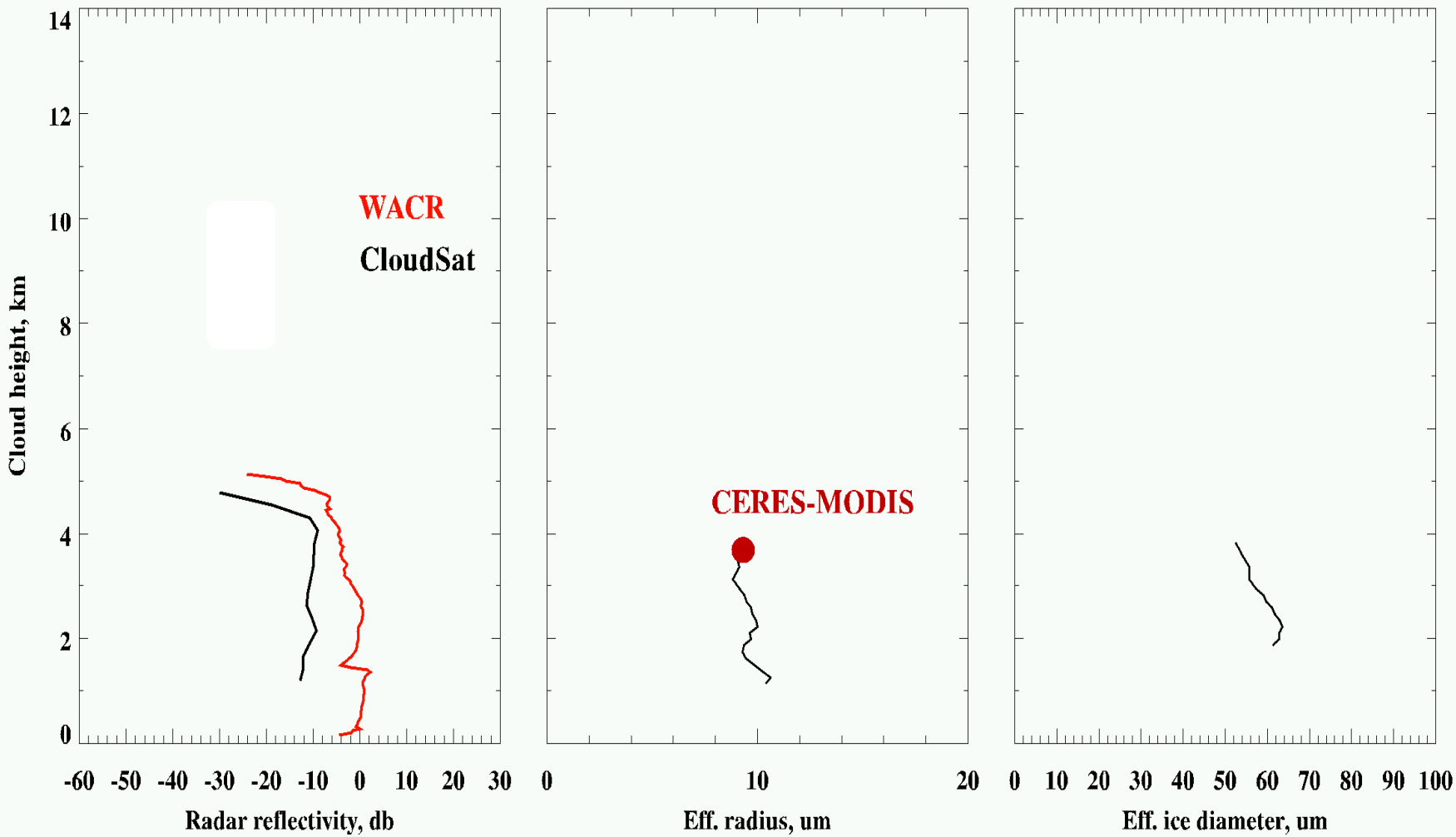
Case 2



There is some difference, but they are at the same range and Cloudsat Is about 10 km away from AMF-China.



Case 2: 20081116



1) ARM radar reflectivity is slightly higher than CloudSat.
2) MODIS retrieved effective radius agree very well with CloudSat retrievals.

Conclusions

1) Cloud height comparison:

Most of CERES-MODIS effective cloud heights H_{eff} fall within ARM radar-lidar derived cloud bases & tops, and have highest correlation with cloud top

2) Cloud Microphysics comparison:

➔The re difference between ARM and MODIS is 1.7 μm with low correlation because MODIS re represents cloud top.

➔Correlations for optical depth and LWP are high, but MODIS values are smaller than ARM results

Conclusions (Cont')

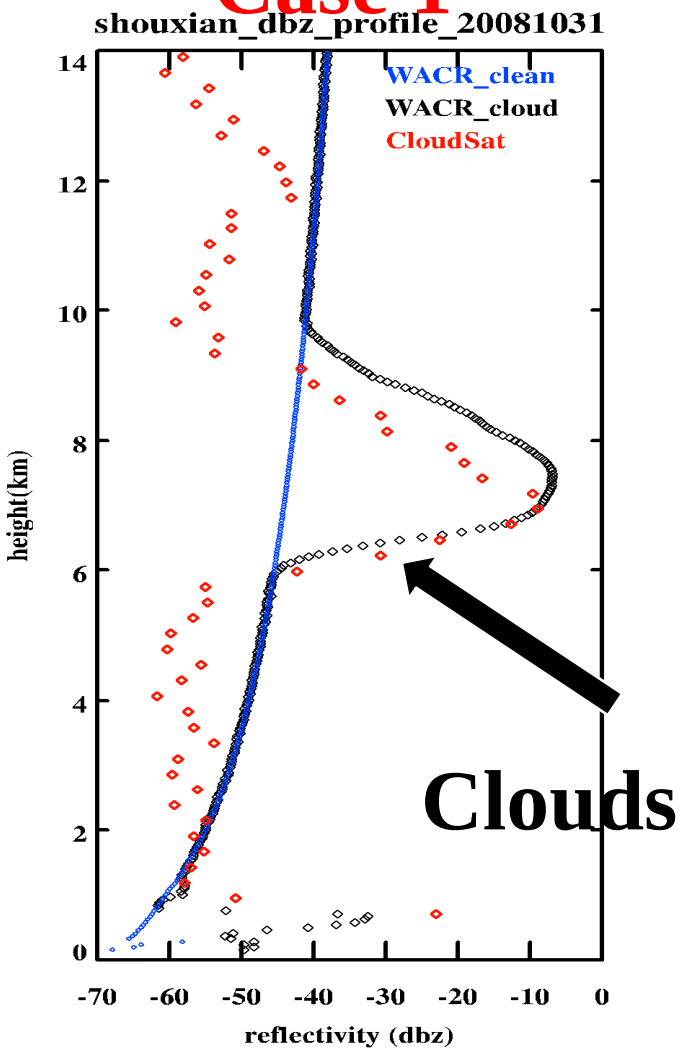
3) Cloud Profile comparison:

- ARM and CloudSat radar reflectivity agree well in both cases.
- CERES-MODIS retrieved liquid and ice particle size agree well with CloudSat retrievals. Only 2 samples.

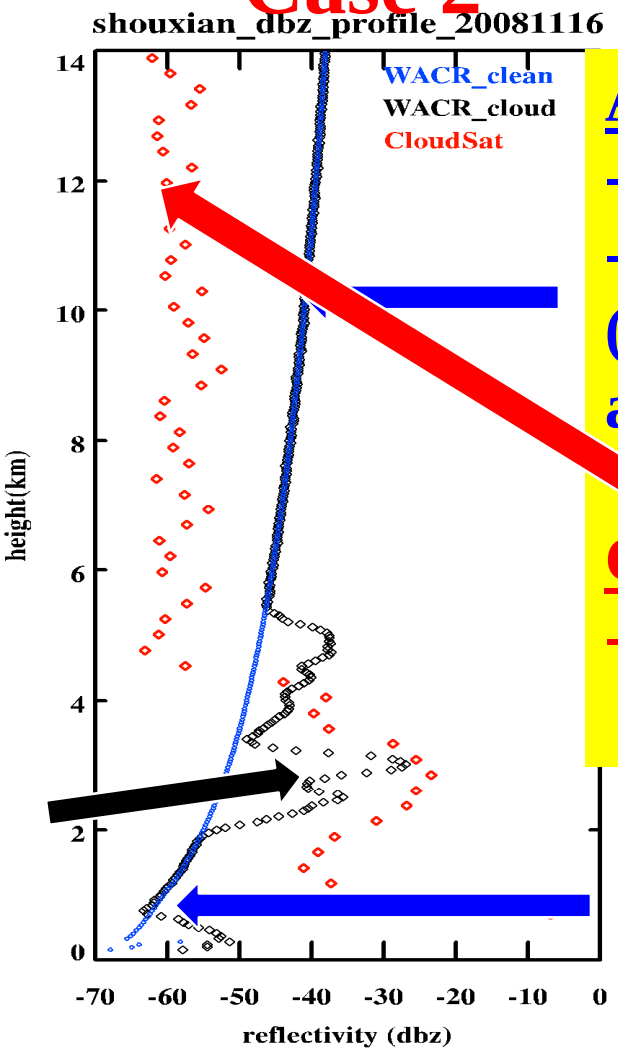
Thanks for your attention

What are sensitivities of ARM cloud radar and CloudSat (94 GHz)

Case 1



Case 2



ARM (blue line):
-60 dbz at 1 km
-40 dbz at 10 km
(due to water vapor attention)

CloudSat (red)
-60 dbz at upper level

CloudSat/CALIPSO (CC)

- Part of A-train constellation of satellites
  - Trails Aqua by one minute
- CloudSat: On-board 94 GHz cloud profiling radar
  - Obtains cloud profile information in addition to cloud microphysical properties
  - 1.7 km along-track resolution by 1.4 km cross-track resolution
- CALIPSO: On-board Cloud Aerosol Lidar
  - Operates at 532 and 1064 nm
  - 100 m footprint
  - 333 m horizontal resolution
  - 30-60 m vertical resolution